

A new species of deep-water skate, *Rajella eisenhardti*, (Chondrichthyes: Rajidae) from the Galápagos Islands

Douglas J. Long and John E. McCosker

(DJL) Department of Ichthyology, (JEM) Department of Aquatic Biology, California Academy of Sciences, Golden Gate Park, San Francisco, California 94118, U.S.A.

Abstract.—A new species of skate, *Rajella eisenhardti*, is described from two specimens collected from deep-slope (757–907 m) areas off the Galápagos Islands. It is similar to another eastern Pacific species, *Rajella nigerrima* de Buen 1960, but differs in part by having more precaudal vertebrae and more pectoral radials, a wider and longer disc, a longer snout, larger gill openings with wider interspaces, longer anterior and shorter posterior pelvic lobes, and in coloration and spination.

The skate fauna of the eastern central Pacific, extending from southern Mexico to northern Peru, contains at least 12 species (McEachran & Miyake 1984, 1990; McEachran 1995). Galápagos records are limited to those of *Bathyraja spinossima*, *Gurgesiella furvescens* and *Raja velezi* (McEachran & Compagno 1979; McEachran 1995; Grove & Lavenberg 1997). McEachran and Miyake (1984) also reported a specimen of *Bathyraja* cf. *richardsoni* from near the Galápagos Islands (00°11.3'S, 97°27.7'W, 1710 m), but not within the archipelago. The recent capture of two specimens of an undescribed *Rajella* using the manned submersible *Johnson Sea-Link* during deep-water dives around the Galápagos Islands (McCosker et al. 1997) has prompted this paper.

Methods

Abbreviations: CAS = California Academy of Sciences, ichthyological collections; TCWC = Texas Cooperative Wildlife Collection; TL = total length.

Measurements and meristic counts follow current methodology in McEachran & Miyake (1984, 1988) and Stehmann (1995). Measurements were made with dial calipers and recorded to the nearest 0.1 mm. Ver-

tebral and radial counts were made from radiographs.

Rajella eisenhardti, new species
Figs. 1–2; Table 1

Diagnosis.—The new species can be distinguished from other *Rajella* species by a combination of its moderately long tail (tail length greater than distance from snout to cloaca) that is largely free of denticles on the ventral side; three rows of caudal thorns that begin at level of anterior pelvic lobe; 67–68 predorsal caudal vertebrae; 68–69 pectoral radials; disc width 55.0–58.5% of TL and disc length 50.0–51.2% of TL; snout-vent length 44.1–46.4% of TL; pre-orbital snout length 13.4–14.1% of TL; and ventrum darker than dorsum, with distinct light areas around mouth and nasal areas, gill openings, abdomen, cloaca, and tips of rostrum, tail, and pectoral fins.

Holotype: CAS 86817, an immature male (384.5 mm TL) caught with a siphon hose on the bottom at 757 m off Cabo Rosa (01°04.74'S, 91°11.08'W), Isla Isabella, Galápagos Islands, by J. E. McCosker aboard the submersible *Johnson Sea-Link* on 11 Nov 1995.

Paratype: CAS 86561, an immature male (254.1 mm TL) caught with a siphon hose

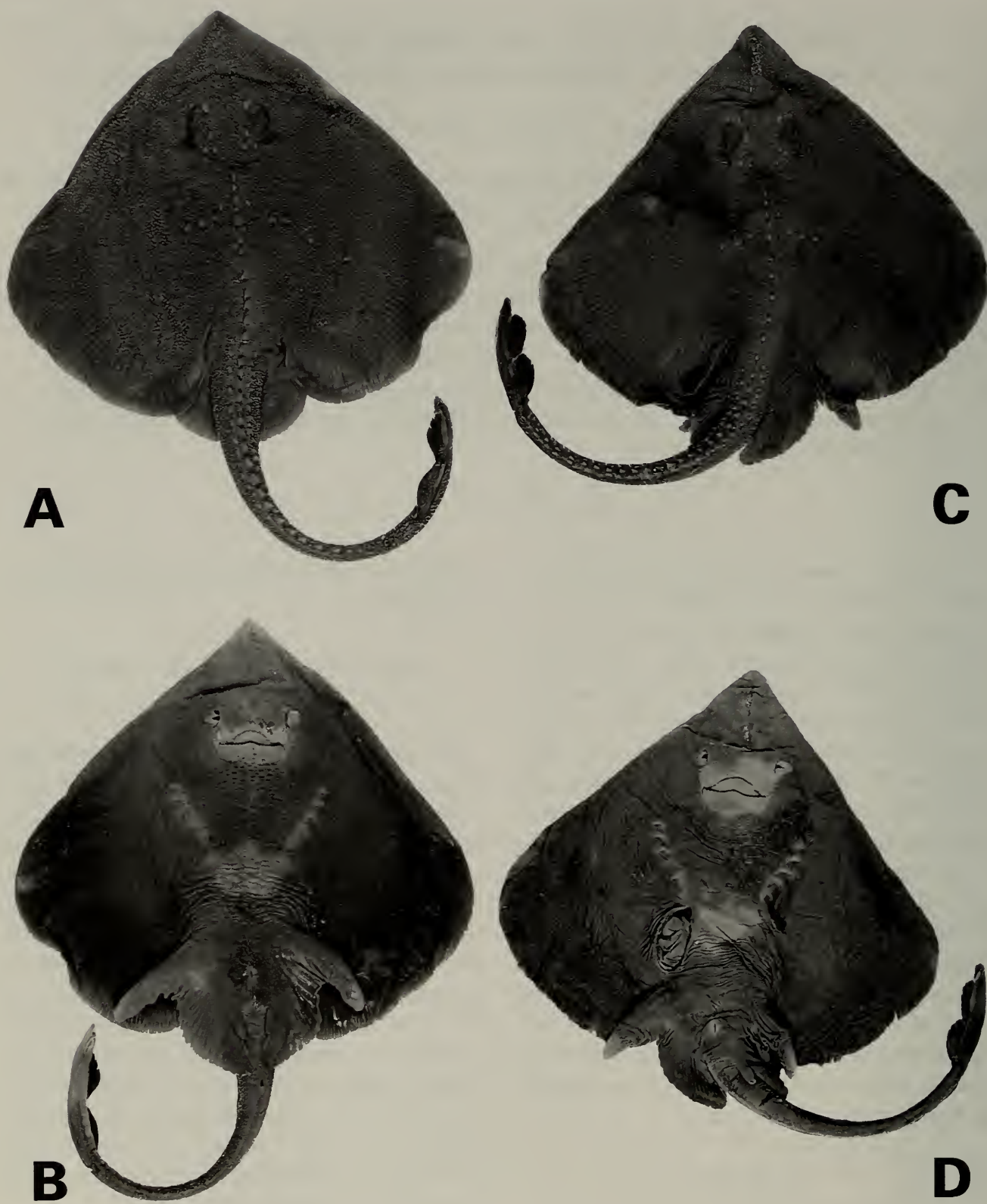


Fig. 1. Preserved types of *Rajella eisenhardti*. A–B, dorsal and ventral views of holotype, CAS 86817 (384.5 mm TL); C–D dorsal and ventral views of paratype, CAS 86561 (254.1 mm TL).

on the bottom at 907 m off James Bay ($0^{\circ}26.46'S$, $90^{\circ}19.04'W$), Isla San Salvador (Santiago Island), Galápagos Islands, by J. E. McCosker aboard the submersible *Johnson Sea-Link* on 26 Nov 1995.

TCWC 3881-01, 273 mm TL, juvenile female, trawled off Chile ($35^{\circ}53.5'S$, $72^{\circ}44'W$) at 780–925 m, *Anton Brunn* cruise 18A, sta. 40, 9–10 Aug 1966; TCWC 3885-01, 239 mm TL, juvenile female, trawled off Peru ($03^{\circ}15'S$, $80^{\circ}55'W$) at

Comparative material: *Rajella nigerrima*,



Fig. 2. *Rajella eisenhardti*. Underwater photograph of living paratype (CAS 86561) taken from the submersible *Johnson Sea-Link* on the bottom at 907 m off James Bay, Isla San Salvador (Santiago Island) Galápagos Islands.

945–960 m, *Anton Brunn* cruise 18A, sta. 120, 10 Sep 1966.

Description.—See Table 1 for meristics and measurements. Meristic values described below are listed for the holotype, and values for the paratype are shown in parentheses.

A medium-sized species of *Rajella* (sensu Stehmann 1970, 1978; McEachran & Dunn 1998), its disc heart-shaped and moderately broad, with broadly-rounded outer corners. Disc length 0.88 (0.91) in disc breadth. Anterior margin of disc weakly concave near tip of rostrum, straight to slightly convex to widest part of pectorals. Axis of greatest width 0.83 (0.84) times distance from tip of snout to axil of pectoral fins. Snout to mid-cloaca 2.15 (2.26) times in total length.

Preorbital length 4.0 (3.5) times orbit length; preoral length 1.87 (1.98) times internarial distance. Interorbital distance 1.16 (0.96) times orbit length; orbit length 1.48 (1.85) times spiracle length. Anterior nasal lobe laterally expanded to form a nasal curtain, weakly convex anteriorly and finely-fringed laterally and posteriorly. Posterior nasal flap well-developed, extending to near corner of mouth; a single projection on lateral side of flap with fine fringes on the lateral posterior edges, with a smooth margin medially; length of flap 0.32 (0.29), and

width 0.59 (0.57), into preoral length; space between fimbriae 0.30 (0.29) into preoral length.

Distance between first gill slits 1.95 (2.15) times distance between nares; distance between fifth gill slits 1.22 (1.33) times distance between nares; length of first gill slit 1.20 (1.11) times length of fifth gill slit. Third gill slit largest, 0.26 (0.27) times distance between nares, fifth gill slit 0.16 (0.19) times distance between nares, only slightly smaller than first, 0.19 (0.21) times distance between nares.

Pelvic fins deeply incised; anterior lobe long and moderately narrow, bluntly tapered and rounded distally; length of anterior lobe 1.59 (1.46) times length of posterior lobe. Tail long, gradually tapering to tip; distance from mid-cloaca to caudal tip 1.15 (1.26) times distance from snout to cloaca. Base of tail moderately narrow, 9.3% (9.2%) of cloaca to caudal tip length, and moderately convex dorsally, weakly concave ventrally becoming flattened distally. Lateral folds originating well behind the base of tail and continue along length to just anterior of caudal tip where it ends as small lobed flap. Dorsal fins low and rounded; first fin only slightly larger than second and similarly shaped, no space between dorsal fins or between second dorsal and epichordal caudal lobe.

Dorsum entirely covered with fine denticles, including tail and dorsal fins, except on the lateral and posterior margins of the pectoral fins; pelvic fins free of denticles and anterior pelvic lobes smooth, but base of pelvic with fine denticles in the paratype. Larger denticles and thorns with oval or oblong bases, often with weak longitudinal ridges and anteriorly curving tips. Larger denticles on rostral shaft; one to two thorns anterior to each orbit, three posterior to each orbit, and one thorn on each side of the inner orbit. Five thorns on nuchal midline, three on each scapular lateral to the midline, 6–7 thorns on post-scapular midline anterior to the tail. Three rows of thorns on the dorsal surface of the tail be-

Table 1.—Measurements (in mm) and percentages of total length (in parentheses) of *Rajella eisenhardti* compared to percentages of total length of *R. nigerrima* (5 males, 6 females; data from McEachran & Miyake, 1984).

	<i>Raja eisenhardti</i>		<i>R. nigerrima</i> (n = 11)	
	Holotype CAS 86817	Paratype CAS 86561	Range	Mean
Total length	384.5	254.1	139–374	—
Snout to mid-cloaca	178.5 (46.4)	112.3 (44.1)	40–44	43
Disc width	225.0 (58.5)	140 (55.0)	51–53	52
Disc length	197.0 (51.2)	127.0 (50.0)	46–49	48
Head length	104.8 (27.3)	63.0 (24.8)	NA	NA
Snout length (preorbital)	54.3 (14.1)	34.3 (13.4)	10.2–12.8	11.0
Snout length (preoral)	57.5 (14.9)	35.9 (14.1)	12.6–14.5	13.9
Snout to maximum width	132.0 (34.3)	78.0 (30.6)	31–35	32
Snout to pectoral axis	164.5 (42.8)	104.8 (41.2)	NA	NA
Prenasal length	47.7 (12.4)	31.4 (12.3)	9.6–11.5	11.0
Orbit diameter	13.5 (3.5)	9.8 (3.8)	3.7–4.8	4.3
Interorbital distance	15.7 (4.0)	9.5 (3.7)	3.3–3.6	3.5
Spiracle length	9.1 (2.3)	5.8 (2.2)	1.5–2.3	1.8
Orbit and spiracle length	19.4 (5.0)	12.3 (4.8)	3.4–5.2	4.6
Distance between spiracles	28.0 (7.2)	17.7 (6.9)	6.1–6.8	6.3
Mouth width	28.7 (7.4)	18.7 (7.3)	6.2–7.2	6.9
Distance between nostrils	30.8 (8.0)	18.1 (7.1)	6.5–7.1	7.0
Nasal curtain length	18.6 (4.8)	10.3 (4.1)	NA	NA
Nasal curtain width	34.0 (8.8)	20.5 (8.1)	NA	NA
Width of 1st gill opening	5.9 (1.5)	3.8 (1.4)	1.0–1.5	1.2
Width of 3rd gill opening	8.1 (2.1)	4.9 (1.9)	1.0–1.5	1.2
Width of 5th gill opening	4.9 (1.2)	3.4 (1.3)	0.6–1.1	0.8
Distance betw. 1st gill openings	60.3 (15.6)	38.9 (15.3)	13.0–14.5	13.8
Distance betw. 5th gill openings	37.6 (9.7)	24.1 (9.4)	8.1–8.8	8.5
Length of anterior pelvic lobe	63.9 (16.6)	41.3 (16.2)	10.4–14.7	12.9
Length of posterior pelvic lobe	40.2 (10.4)	28.3 (11.1)	11.8–16.0	14.9
Cloaca to 1st dorsal fin	142.8 (37.1)	100.2 (39.4)	41–44	42.0
Cloaca to caudal origin	188.5 (49.0)	134.3 (52.8)	47–57	54.0
Cloaca to caudal tip	206.1 (52.5)	141.8 (55.8)	50–60	57.0
Caudal lobe length	11.6 (3.0)	8.9 (3.5)	NA	NA
1st dorsal height	21.7 (5.6)	15.0 (5.9)	NA	NA
1st dorsal base	22.5 (5.8)	16.1 (6.3)	NA	NA
2nd dorsal height	21.1 (5.5)	12.6 (5.0)	NA	NA
2nd dorsal base	22.8 (5.9)	16.5 (6.5)	NA	NA
Tail width at base	19.2 (5.0)	13.1 (5.2)	NA	NA
Tail width at 1st dorsal origin	6.9 (1.8)	5.0 (2.0)	NA	NA
Tail thickness at base	13.6 (3.5)	7.8 (3.1)	NA	NA
Tail width at 1st dorsal origin	4.5 (1.2)	3.2 (1.3)	NA	NA
No. of upper/lower tooth rows	48/32	46/42	36–46/36–46	42.4
No. of trunk vertebrae	29	28	27–30	28.6
No. of predorsal caudal vert.	67	68	59–65	62.6
No. of pectoral radials	69	68	61–65	63.0
No. of pelvic radials	19	17	NA	NA

ginning at the mid-level of the pelvic fins and continuing to first dorsal fin; median caudal thorns 24 (23); lateral caudal thorns numbering 38–39 (19–20), thorns diminishing along the tail. Ventral surface of holo-

type entirely smooth and bare of denticles; ventral surface of paratype smooth except for some small denticles on ventrolateral margins of tail.

Upper and lower jaws slightly arched;

teeth in quincunx arrangement with small short median crowns becoming more blunt and flattened distally; upper tooth rows 48 (46), lower rows 32 (42). Trunk vertebrae 29 (28), predorsal caudal vertebrae 67 (68). Pectoral radials 69 (68), pelvic radials 19 (17).

Color after preservation: Holotype purplish gray and paratype light brownish gray dorsally; both with whitish blotch on the dorsal edge of the pectoral fin tip; ventral surface darker except for distinct whitish areas on the anterior tip of the rostrum, anterior and posterior to the mouth, around the nostrils, around each gill opening, around the cloaca, on the abdomen, on the tips of the anterior pelvic fin lobes, and at the tip of the tail; light area between abdomen and gill openings connected by a V-shaped mark. Thorns and large denticles whitish, smaller denticles same color as surrounding skin. Color in life (based on an underwater photo of the paratype): dorsal interior of disc, pelvic base, and tail pale brown to grayish; rostrum, dorsal fins, and margins of pectoral and pelvic fins blue-gray.

Etymology.—Named in honor of E. Roy Eisenhardt, director emeritus of the California Academy of Sciences, who has generously assisted us and our colleagues.

Discussion

The subgenus *Rajella* was recently elevated to full generic status (McEachran & Dunn 1998), and includes 14 species found in the Atlantic, Pacific, and Indian oceans. These are: *R. annandalei* Weber, 1913; *R. barnardi* (Norman 1935); *R. bathyphilia* (Holt & Byrne 1908); *R. bigelowi* (Stehmann 1978); *R. caudaspinosa* (Von Bonde & Swart 1923); *R. dissimilis* (Hulley 1970); *R. fuliginea* (Bigelow & Schroeder 1954); *R. fyllae* (Lütken 1887); *R. kukujevi* (Dolganov 1985); *R. leopardus* (Von Bonde & Swart 1923); *R. nigerrima* (de Buen 1960); *R. purpuriventralis* (Bigelow & Schroeder 1962); *R. ravidula* (Hulley 1970); and *R.*

sadowskii (Krefft & Stehmann 1974). Our specimens differ from all of these species by a combination of morphometrics, meristics, spination, and coloration. It most closely resembles the only other eastern Pacific *Rajella*, *R. nigerrima*, a species that ranges from Peru to Chile (McEachran & Miyake 1984).

Rajella nigerrima has a checkered taxonomic history. It was first placed in the genus *Breviraja* (de Buen 1960; Stehmann & Seret 1983), later placed in the subgenus *Malacoraja* (McEachran & Compagno 1982) which was subsequently elevated to generic rank (McEachran 1984; McEachran & Miyake 1984; Ishihara & Ishiyama 1986), later reclassified in *Raja*, subgenus *Rajella* (McEachran & Miyake 1990; Pequeño & Lamilla 1993), and has recently been elevated to generic status (McEachran & Dunn 1998). The types of *R. nigerrima* are believed lost and a neotype was designated by McEachran & Miyake (1984).

Our comparisons with the original description of *R. nigerrima*, specimens described by McEachran & Miyake (1984), and preserved specimens we examined, show significant meristic and morphological differences (Table 1). *Raja nigerrima* has fewer predorsal caudal vertebrae and fewer pectoral radials. There are several important proportional differences between *R. eisenhardti* and *R. nigerrima* including the latter's smaller preorbital length in relation to orbit length, and its first gill slit is longer than its fifth gill slit. And (in relation to total length) *R. nigerrima* has a shorter snout, a shorter snout to mid cloaca length, a reduced disc length and width, a narrower mouth, narrower interorbital and interspiracular distances, shorter anterior pelvic lobes, larger posterior pelvic lobes, and narrower third and fifth gill openings.

Rajella nigerrima has three rows of dorsal thorns posterior to the suprascapular, but *R. eisenhardti* has three rows beginning at the middle edge of the pelvic fin; *R. nigerrima* has three dorsal and lateral rows of thorns from the base of the tail to the first

dorsal fin, but in *R. eisenhardti* the caudal thorns begin at the level of the anterior pelvic lobes. The underside of the tail in *R. nigerrima* has many small, sharp denticles except for a very narrow strip along the midline, which is bare; in *R. eisenhardti*, the underside is completely bare (holotype) or has spinelets only on the lateral margins of the tail's underside (paratype).

The color of *R. nigerrima* is brown, with some indistinct lighter areas on the underside around the mouth, vent, abdomen, and around the gills; in *R. eisenhardti*, the body color is gray to brownish gray with very distinct whitish areas around the nares, mouth, gills, vent, and abdomen, and on the tips of the rostrum, tail, and pectoral fins and pelvic lobes.

Acknowledgements

For assistance and permission to study in Ecuador, we sincerely thank: Ing. O. Aguirre, Subdirector de Pesca de Galápagos; C. V. Zambrano, Biól. H. Müller, Dr. F. Ormaza-González, Instituto Nacional de Pesca; Lcdo. A. Izurieta Valery and Biól. E. Amador, Parque Nacional Galápagos; Teniente A. Villacis, Capitán de Puerto de Isidro Ayora; and Dr. C. Blanton, Director de Estación Científica Charles Darwin. Many other individuals have assisted us in this project, and in particular we wish to thank: R. G. Gilmore and the staff of the Harbor Branch Oceanographic Institution for the operation of the Vessel *Seward Johnson* and its submersible, the *Johnson Sea-Link*; J. D. McEachran of Texas A&M University for loan of comparative material and critical review of an earlier draft of this manuscript; E. R. Eisenhardt, D. Lin, and B. E. Carlson for photographic assistance; W. Eschmeyer, D. Catania, and J. D. Fong of the California Academy of Sciences; and the David and Lucile Packard Foundation and the Discovery Channel for grants and other assistance.

Literature Cited

- Bigelow, H. B., & S. C. Schroeder. 1954. A new family, a new genus, and two new species of batoid fishes from the Gulf of Mexico.—*Breviora* 24: 1–16.
- , & ———. 1962. New and little known batoid fishes from the western Atlantic.—*Bulletin of the Museum of Comparative Zoology* 128:162–244.
- de Buen, F. 1960. Tiburones, rayas y quimeras en la Estación de Biología Marina de Montemar, Chile.—*Revista de Biología Marina* 10(1–3):3–50.
- Dolganov, V. N. 1985. *Raja (Rajella) kukujevi* sp. n. (Elasmobranchii, Rajidae) from the North-Atlantic Ridge.—*Zoologicheskii Zhurnal* 64(2): 304–307.
- Grove, J. S., & R. J. Lavenberg. 1997. The Fishes of the Galápagos Islands. Stanford University Press, Stanford. 863 pp.
- Holt, E. W. L., & L. W. Byrne. 1908. Second report on the fishes of the Irish Atlantic slope.—*Fisheries Ireland Scientific Investigations* 5:141–201.
- Hulley, P. A. 1970. An investigation of the Rajidae of the west and south coasts of southern Africa.—*Annals of the South African Museum* 55(4): 151–220, 13 pls.
- Ishihara, H., & R. Ishiyama. 1986. Systematics and distribution of the skates of the north Pacific (Chondrichthyes, Rajoidei). Pp. 269–280 in T. Uyeno, R. Arai, T. Taniuchi, and K. Matsuura, eds., *Indo-Pacific Fish Biology: Proceedings of the Second International Conference on Indo-Pacific Fishes*. Ichthyological Society of Japan, Tokyo.
- Kreffft, G., & M. Stehmann. 1974. Ergebnisse der Forschungsreisen des FFS "Walther Herwig" nach Sudamerika: XXXIII. *Raja (Rajella) sadowskii* spec. nov. (Chondrichthyes, Batoidei, Rajidae), ein weiterer neuer Roche vom südwestatlantischen Kontinentalabhang.—*Archiv Für FischereiWeissenschaftliche* 25:33–50.
- Lütken, C. F. 1887. Korte bidrag til nordisk ichthyographi. VI. En for Grønlandshavet ny Rokkeart.—*Videnskabelige Meddelelser Naturhistorik Forening Köbenhavn* 1887:1–4.
- McCosker, J. E., G. Merlen, D. J. Long, R. G. Gilmore, & C. Villon. 1997. Deepslope fishes collected during the 1995 eruption of Isla Fernandina, Galápagos.—*Noticias de Galápagos* 58:22–26.
- McEachran, J. D. 1984. Anatomical investigations of the New Zealand skates *Bathyraja asperula* and *B. spinifera*, with an evaluation of their classification within the rajoidei (Chondrichthyes).—*Copeia* 1984(1):45–58.
- . 1995. Rajidae. Pp. 773–777 in W. Fischer, F. Krupp, W. Schneider, C. Sommer, K. E. Carpenter and V. H. Niem, eds., *Guía FAO Para la Identificación de Especies para los Fines de la*

- Pesca. Pacifico centro-oriental. Vol. II. Vertebrados—Parte 1:647–1200.
- , & L. J. V. Compagno. 1979. A further description of *Gurgesiella furvescens* with comments on the interrelationships of Gurgesiellidae and Pseudorajidae (Pisces: Rajoidei).—Bulletin of Marine Science 29(4):530–553.
- , & ———. 1982. Interrelationships of and within *Breviraja* based on anatomical structures (Pisces: Rajoidei).—Bulletin of Marine Science 32(2):399–425.
- , & K. A. Dunn. 1998. Phylogenetic analysis of skates, a morphologically conservative clade of elasmobranchs (Chondrichthyes: Rajidae).—Copeia 1998 (2):271–290.
- , & T. Miyake. 1984. Comments on the skates of the tropical eastern Pacific: one new species and three new records (Elasmobranchii: Rajiformes).—Proceedings of the Biological Society of Washington 97(4):773–787.
- , & ———. 1988. A new species of skate from the Gulf of California (Chondrichthyes, Rajoidaei).—Copeia 1988(4):877–886.
- , & ———. 1990. Zoogeography and bathymetry of skates (Chondrichthyes, Rajoidei). Pp. 305–326 in H. L. Pratt, S. H. Gruber and T. Taniuchi, eds., Elasmobranchs As Living Resources. National Oceanographic and Atmospheric Administration Technical Report 90.
- Norman, J. R. 1935. Coast fishes. Part I. The south Atlantic.—“Discovery” Reports 12:1–58.
- Pequeño, G. & J. Lamilla. 1993. Batoideos comunes a las costas de Chile y Argentina-Uruguay (Pisces: Chondrichthyes).—Revista Biología Marina, Valparaíso 28(2):203–217.
- Stehmann, M. 1970. Vergleichend morphologische und anatomische Untersuchungen zur Neuordnung der Systematik der nordostatlantischen Rajidae (Chondrichthyes, Batoidei).—Archiv für Fischerei- und Meeresforschung Wissenschaftliche 21:73–164.
- . 1978. *Raja* “*bathyphilia*”, eine doppelart des subgenus *Rajella*: wiederbeschreibung von *R. bathyphilia* Holt & Byrne, 1908 und *Raja bigelowi* spec. nov. (Pisces, Rajiformes, Rajidae).—Archiv für Fischerei- und Meeresforschung Wissenschaftliche 29(1/2):23–58.
- . 1995. First and new records of skates (Chondrichthyes, Rajiformes, Rajidae) from the west African continental slope (Morocco to South Africa), with descriptions of two new species.—Archive of Fishery and Marine Research 43(1): 1–119.
- , & B. Seret. 1983. A new species of deep-water skate, *Breviraja africana* sp. n. (Pisces, Batoidea, Rajidae), from the eastern Central Atlantic slope, and remarks on the taxonomic status of *Breviraja* Bigelow & Schroeder, 1948.—Bulletin de Muséum National d’Histoire Naturelle, Paris, 4th series, section A, 3:903–925.
- Von Bonde, C., & D. B. Swart. 1923. The Plagiostoma (skates and rays) collected by the S. S. “Pickle”.—Union of South Africa Fisheries and Marine Biological Survey 3(5):1–22.
- Weber, M. 1913. Die fische der Siboga-Expedition.—Siboga Expedition 57:1–710.